Status of Models, Traveltimes and Raytracers: Computing SSSCs

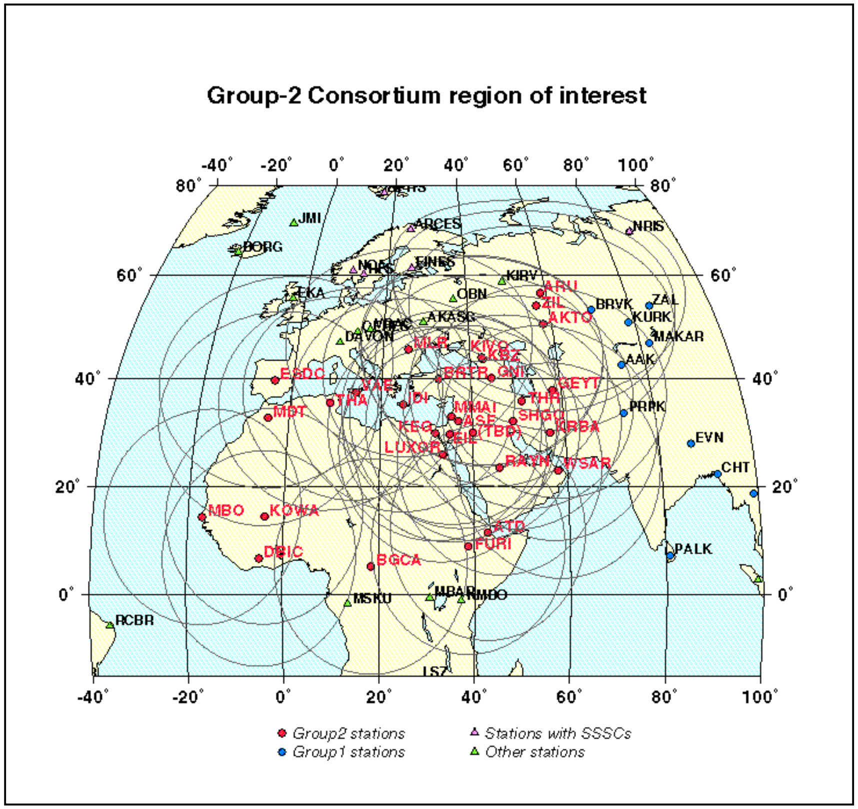
Group 2 Consortium
DTRA Consortium Review, CMR
3/5/01

SAIC:
- Model development
- Traveltime computation
- SSSC computation

University of Colorado, Boulder:
- Model development
- Raytracer development
- SSSC computation

Harvard University:
- Model development
- SSSC computation

Scripps/UCSD:
- Model development
- Model validation



Project Goals

- Model Construction
- Model Validation
- Raytracer Development
- SSSC computation
  - 1000 stations, 2 models, 4 phases
- Error Estimation

GT Information

Cluster Analysis

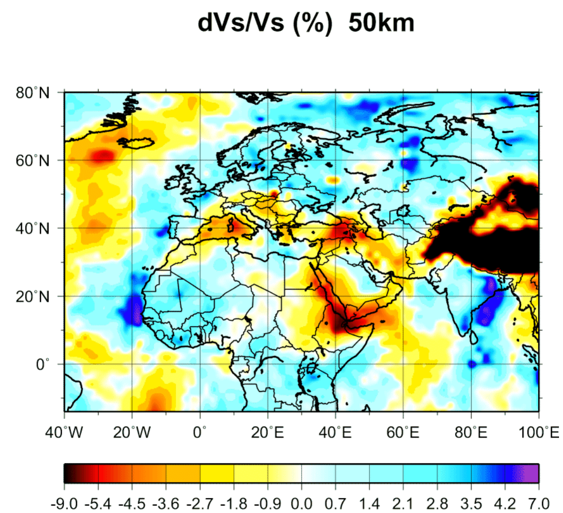
Validation Tests

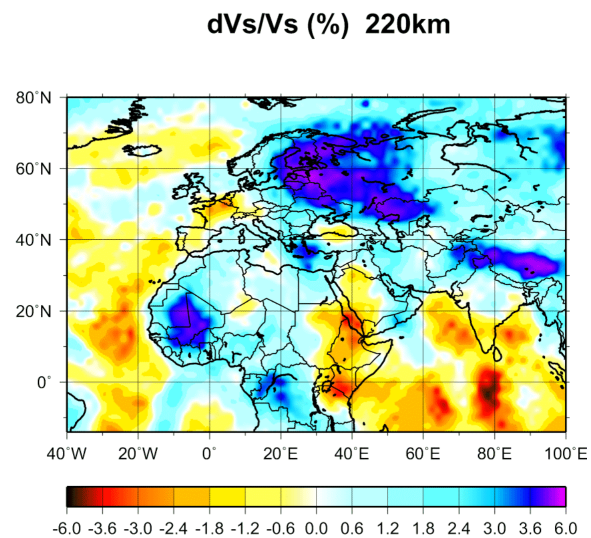
Event Relocations

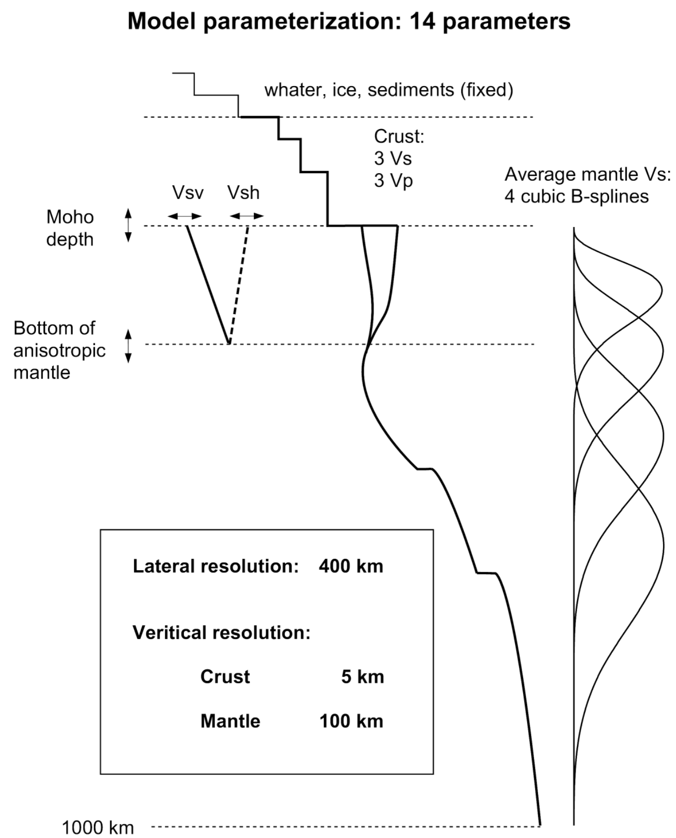
Project Milestones

- Model Construction
  - Developed Colorado 3-D Crust + Upper Mantle Model
  - Developed Harvard 3-D Whole Mantle Model
  - Developed SAIC Regionalized Crustal Model
  - Developing Scripps High-Resolution Sediment Model
- Model Validation
  - Model validation Tests have started with preliminary models (Scripps)
- Raytracer Development
  - Developed two separate methodologies
  - Being delivered and installed at SAIC
- SSSC Computation
  - Started at SAIC and CU, Boulder
- Error Estimation
  - Preliminary Methodologies developed
  - Working group created

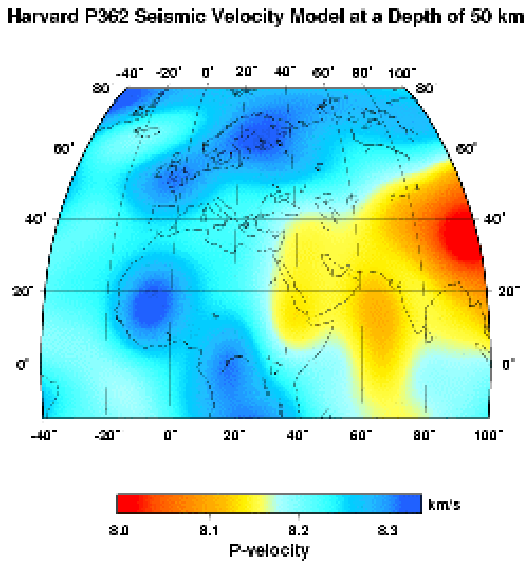
CUB1.0 Model
(Crust + Mantle, Vp and Vs)

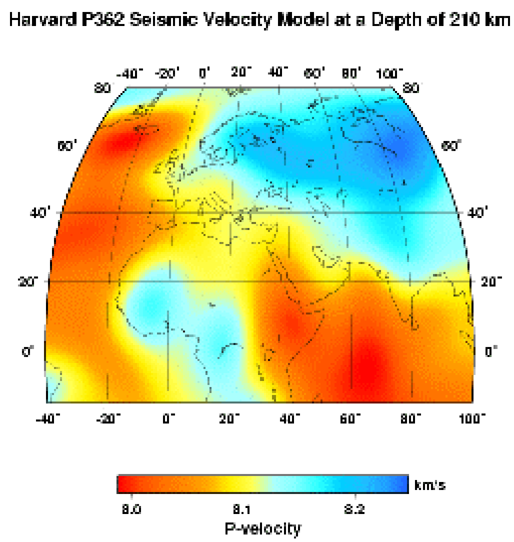






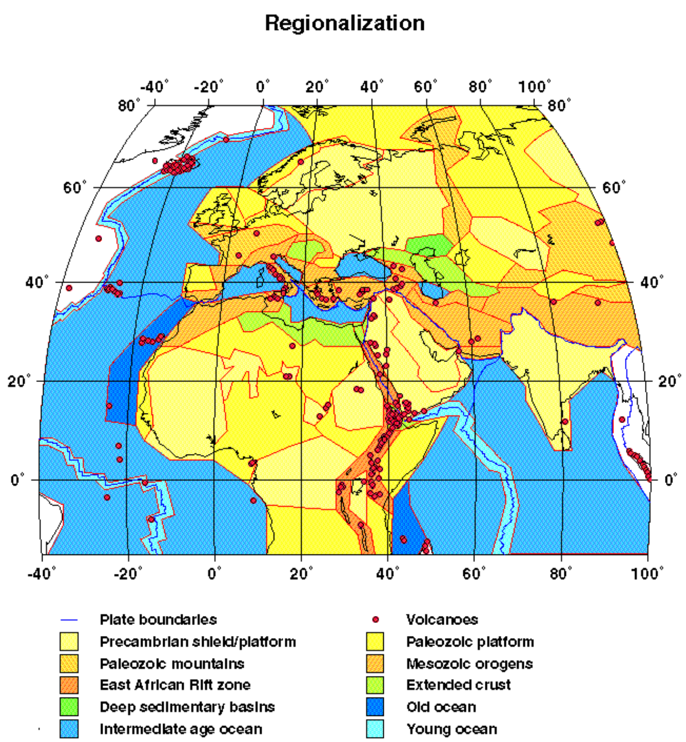
Harvard Model (Mantle, Vp and Vs)





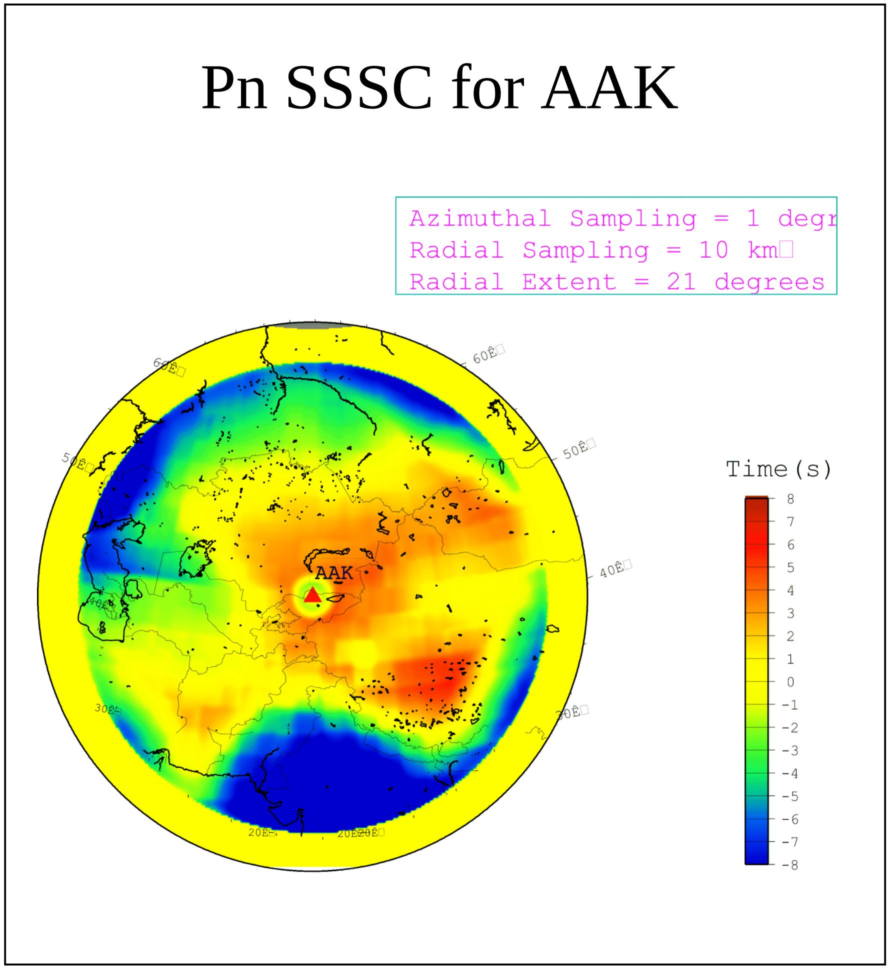
- Data Assembly
  - Relocation of sources in a prior 3-D model
  - Formation of summary rays (6,26,000 rays)
  - Crustal correction (CRUST5.1)
  - Surface wave dispersion (60,000 Love and Rayleigh paths between 35 – 150 s)
- Modeling
  - Spherical spline representation
  - Parameterization: 25 km – CMB
  - Large scale structures

SAIC Model (Crust Vp, Vs)



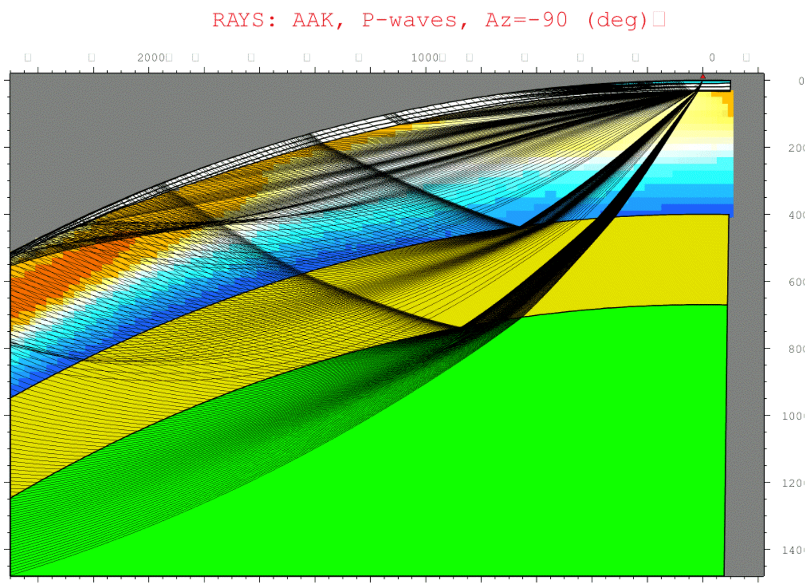
- Based on seismic regionalization using:
  - Tectonic maps
  - Published literature
  - Existing regionalizations
- Each region has a 1D velocity model (P, S)
- Merged with Harvard models
- http://g2calibration.cmr.gov/calibration/protected/Regionalization

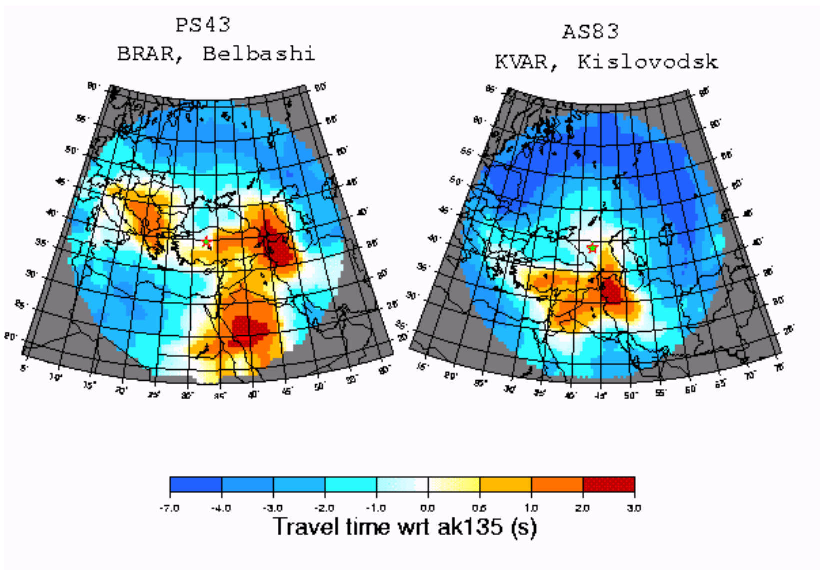
3-D Raytracing



- Finite Difference Calculations
  - Finite Difference travel time calculator of Podvin and Lecomte (1991) and implemented by Villasenor and Ritzwoller
  - Allows different propagation modes (diffraction, head, etc)
  - Computed for a 2 km X 2 km grid
- Limitations
  - Computationally intensive
    - Time: 300 mins/SSSC
    - Error: < 0.25 s
  - Difficult to compute later arrivals

3-D Raytracing (Contd.)

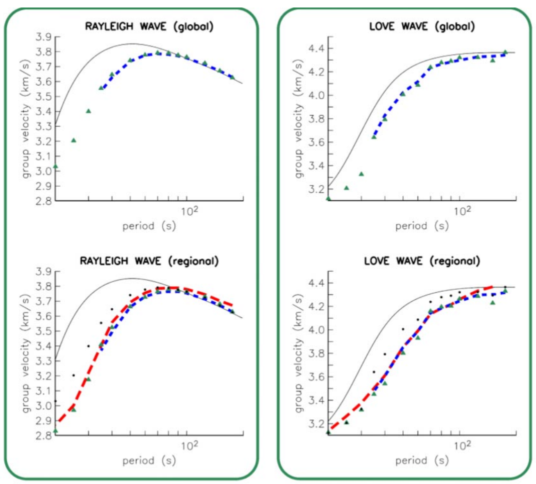




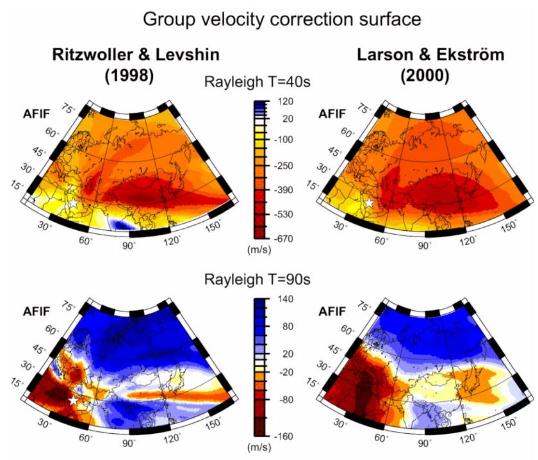
- D2TRACERDN Code
  - Phase specific
  - Developed by CU, Boulder
  - Calculation of refracted P or S travel times in 3D laterally inhomogeneous media with curved interfaces by the ray method.
  - Program constructs P or S 3D travel time table (TTT) within 20 degree from an arbitrary station for the sources at depths 10, 20, 30, 40, 50 km
  - D2tracerdn is based on the well known Psencik-Cerveny ray method for 2D layered structures.
  - Time: 20 mins / SSSC

Model Validation

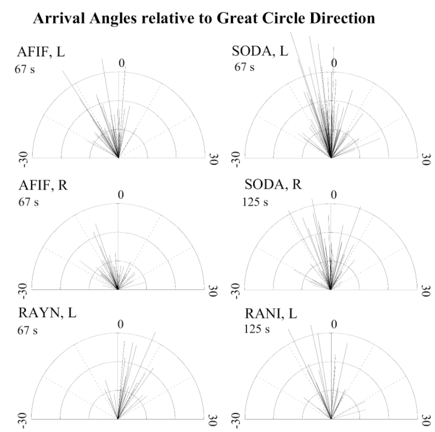
- **Model validation tests using independent surface wave datasets have begun at Scripps**
- **The following parameters are being evaluated:**
  - **Dispersion curves: phase velocity (Harvard) and group velocity (Colorado)**
  - **Surface wave maps: model based predictions**
  - **Surface wave arrival angles / polarization data**



Comparison between measured and predicted path averaged group velocities for the Saudi array. Green triangles represent measurements and the predictions are for PREM (black), Harvard (blue) and Colorado (Red).



Group velocity correction surfaces wrt anisotropic PREM, plotted at the source location. Models differ signifcantly.



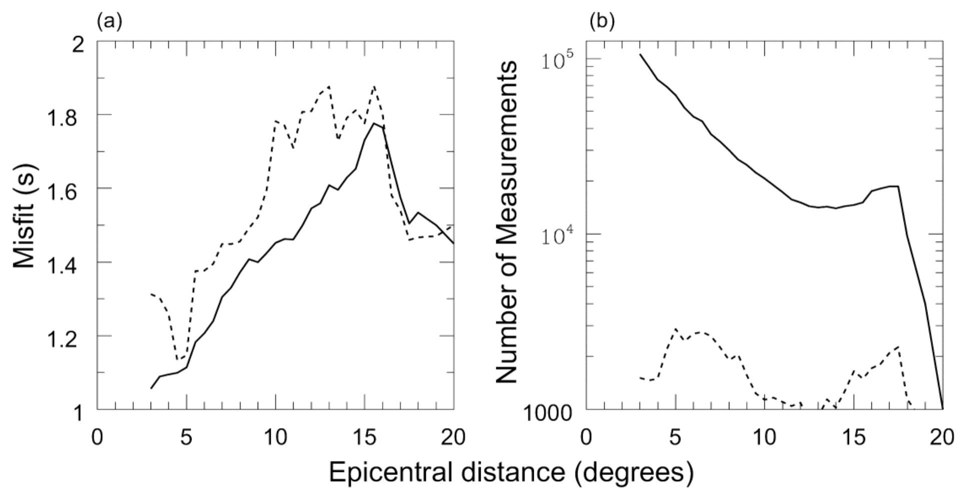
Polarization data highlighting off-great-circle-path arrival and Station misalignment (67 – 125 s).

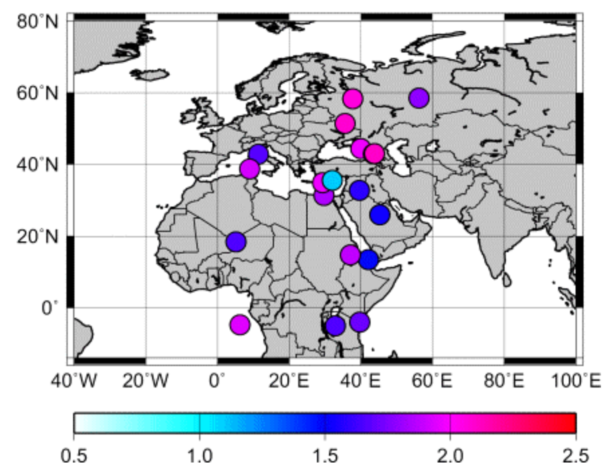
Error Estimation Methodologies

1. Model based: Analyzing the variability between SSSC surfaces computed for the two (HRV and CU) models.
2. Data based: Compute 1-D variogram (epicentral distance vs. TT residual) for all of the stations in the region, including non-IMS stations to get good spatial coverage, using a travel time data set and the 3-D model with which the SSSC's are being generated.
3. Adhoc error bounds based on our knowledge of how well we know the structure in a region. To be vetted by 3-D modelers.
4. The default IASPEI values, maybe in regions of sparse data and/or model coverage.
5. Using corrections derived from JHD analysis of event clusters.
6. Develop a methodology for handling error surfaces where we have reference events.
7. Limited Monte Carlo tests with the models, only if necessary.

Variogram Error Estimation

- Based on 1-D variogram analysis, we will construct region-wide azimuthally independent error surfaces for the SSSCs





Future Work

- Travel Times:
  - Compute phase dependent SSSCs for Pg, Pn, Lg, Sn at 0 km and 10 km depths.
- Travel Time Errors:
  - SSSC error methodology
  - SSSC error estimation
- 3-D Modeling:
  - Validation of current models
  - Estimation of model variability from regionalized models.

Schedule Till June:

Compute Phase 1 SSSCs for four seismic arrivals **with errors** (SAIC, CUB)

Carry out model validation tests (SAIC, Scripps)

Develop algorithm and calculate model errors (SAIC, CUB, Harvard)